



WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Development of an on-the-go Soil Sensor for Identifying Nutrient Management Zones and Improving Water Quality

Focus category: GW, MOD, NPP

Keywords: Chemigation, Nitrogen, and Phosphorus

Duration: May 1, 1999 to May 1, 2000

FY 1998 Federal funds year 1 \$15,000

Non-federal funds allocated: \$31,900 (total) \$18,500 (direct) \$13,400(indirect)

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Congressional district: First

Statement of critical regional or State water problems

A concept guiding this project is that site specific management reduces N nonpoint source (NPS) pollution. Because 25% of South Dakota's population obtains it's drinking water from the Big Sioux Aquifer, and this aquifer is vulnerable to contamination by agricultural activities, developing management practices that minimize the impact of agriculture on water quality while simultaneously maintaining agricultural profitability is important to both rural and urban South Dakota communities.

The NPS reduction occurs because the relationship between N inputs to yield follows a logistic model, while N loss follows an exponential model (Stevenson, 1986). Due to the differences in the two models, under and appropriate fertilized areas contribute very little to NPS pollution, while over fertilized areas contribute progressively more. For example, Larson et al. (1997) estimated nitrate leaching and remaining in the soil profile using LEACHEM in a normal and above rainfall year for 7 different Minnesota soils. They showed the largest advantage of site specific management was during growing seasons where rainfall was above average. Under above normal rainfall conditions site specific management reduced N leaching during the growing season by 16% and the amount of residual N remaining in the growing season, that could be subject to future leaching, by 53%. Similar relationships have been reported between P additions and P concentration in runoff water (Romkens and Nelson, 1974).

Managing for variability would be relatively simple if fields were uniform. However, nonuniformity is the rule rather than the exception in most agricultural fields. Our ability to manage variability is limited by the availability of reliable cost-effective information.

Clearly, innovative, cost-effective sampling and information management decision aids are needed to move agriculture into the information age, improve agronomic profitability and reduce agricultural impacts on the environment. The proposed project uses an innovative approach to integrate an electromagnetic sensor with survey grade DGPS, mathematical models, and basic research investigating landscape processes. We hypothesize that by integrating these components, landscape induced differences can be separated from management induced differences. Once separated, nutrient management zones that account for intrinsic and management variability can be developed.

Grid and soil property-based sampling techniques are used to obtain spatial information for precision nutrient management. Grid sampling is preferred by many managers because highly trained field technicians are not required to collect samples and personal biases are eliminated. However, many practitioners perceive grid sampling to be expensive and unprofitable. Other managers prefer soil property-based sampling because it is perceived to balance the cost of obtaining information with the information value. Soil-property based sampling is not recommended when:

1. field histories are unknown,
2. fertility levels are high or high rates of fertilizer have been applied,
3. manure was applied,
4. the field contained a feedlot,
5. small fields were merged into a larger one, and
6. non-mobile nutrients are important to map (Franzen et al., 1998).

These criteria provide a bases for determining the appropriateness of soil-based sampling. However, they do not specify the length of time that field records should be know, what are high fertility levels, or what happens if manure was applied once 10 years ago. Preliminary research conducted at SDSU showed that the effects of management that occurred during the 1930's impacts nutrient management today, and therefore, field histories that extend 50 years may be required (Chang et al., 1999a). Clearly, 50 years of field records are unavailable for most fields. What is needed are cost effective automated techniques that can provide information, from which long-term management can be assessed.

Nature, scope, and objectives of the research

Theoretically, precision farming is the process of using information to develop more profitable and environmentally sound management systems. Key questions in precision nutrient management are: (I) how can I reduce the cost associated with collecting soil nutrient information; (ii) how can I quickly process information into decisions; and (iii) will management practices designed to account for soil spatial variability improve environmental quality? A guiding concept behind this project is that science-based sampling and decision tools can minimize the cost of obtaining information and also facilitate the conversion of information into improved decisions.

The hypothesis of this proposal is that, by linking watershed process mathematical models with state-of-the-art soil electromagnetic (EM) sensors and survey grade differentially corrected global satellite positioning system (DGPS), management and intrinsic induced variation in the soil apparent electrical conductivity can be separated. Once separated soil management and property-based nutrient management zones can be identified.

The objectives of this project are

To determine the influence of pedogenic processes on soil electrical conductivity. The proposed project is a three year project. Only the methods for the first year are described below. During the second and third years of the study, the findings from objective 1 will be used to develop a model that will help identify different nutrient management zones. The ability to describe these zones will be field tested in years 2 and 3. In addition, resulting impact on water quality will be calculated.

During the first year of a three-year study representative landscapes in South Dakota will be selected for detailed characterization and for developing models relating topography, salt concentration, and climatic conditions. The hill slopes used for this objective will have not previously contained either homesteads or feedlots. Historical field records for each site will be obtained by interviewing the farm manager.

At each site a detailed topographic map will be developed by a Leica survey grade DGPS. Three transects containing high and low points along a representative hill slope will be selected for study. Along each transect, soil samples from each horizon at the different landscape positions will be selected. Soil samples will be analyzed for soil salinity, cation exchange capacity (CEC), plant available nutrients (N, P, K), pH, and soil texture (clay, sand, and silt) by standard techniques. In addition at each sampling point, detailed soil characterization will be conducted, soil series and drainage class determined, and EM measurements taken. Long term climatic information for each site will be obtained from the appropriate USDA-NRCS soil survey report and local weather station data. Findings from these studies will be used to construct model systems relating pedogenic processes to salt accumulation following the approach of Malo and Worchester (1975).

Facilities South Dakota State University has the equipment required to conduct the proposed research. Equipment available include: Geonics EM38, Leica survey grade real time DGPS, Omnistar DGPS, weather stations, TDR, combines equipped with yield monitors and GPS, HPLC, GC, Europa ratio mass spectrometer, Astoria N analyzer series 300, computers with GIS and ERDAS software, and a portable radiometer produced by CID that scans the 300 to 950 nm wavelengths. A collaborator, Aeroborne Data Systems, has an airplane with a GPS/computer controlled digital remote sensing cameras. The remote sensing and GIS laboratories have 300 MHZ pentium PCS with windows NT operating systems. Multiple copies of both ARC/Info and ERDAS software reside on PCS with University works stations. Supported hardware includes color plotters and printers, 8 mm tape drive, CD-rom writers and access to other university resources.